

NJDOT Bureau of Research
QUARTERLY PROGRESS REPORT

Project Title:	Correlation between Multiple Stress Creep Recovery (MSCR) Results and Polymer Modification of Binder					
RFP NUMBER: 2009-09	NJDOT RESEARCH PROJECT MANAGER: Stefanie Potapa					
TASK ORDER NUMBER: RF-CUNY40	PRINCIPAL INVESTIGATOR: Yusuf Mehta					
Project Starting Date: 7/1/2009 Original Project Ending Date: 09/30/2011 Modified Completion Date: 06/30/2012	Period Starting Date: April 1, 2011 Period Ending Date: June 30, 2011					

Task	% of Total Project Budget	Total Budget	% of Task This Quarter	Cost This Quarter	% of Task to Date	Total Cost to Date
1. Comprehensive Literature Review	10%	\$39,893.00	0	0	100%	\$39,893.00
2. To conduct MSCR and ER and compare the recoveries measured from both methods, determine the true grade of the modified binders	50%	\$199,463.00	0%	0	75%	\$149,597.25
3. To conduct Gel Permeation Chromatography (GPC) to determine the polymers in the modified binders Also, to conduct Fourier Transform Infrared Spectroscopy and Nuclear Magnetic Resonance Spectroscopy to determine the polymers in the modified binder.	20%	\$79,785.00	5%	\$3,989.25	90%	\$71,806.54
4. Evaluation of Laboratory mixture performance	10%	\$39,893.00	0%	0	2%	\$797.86
5. To develop appropriate specification limits and the database of mechanical properties of modified binders, mixtures and the type of modification of the binder	5%	\$19,946.00	0%	\$0.00	0%	\$0.00
6. Final Report	5%	\$19,946.00	0%	\$0.00	0%	\$0.00
TOTAL	100%	\$398,926.00		\$3989.25		\$262,094.65

OBJECTIVES

The objectives of this study are:

1. To determine the challenges and successes of using polymer and crumb rubber modified binder from the existing literature and the state of practice. These include types of polymers, test methods to evaluate polymer modified binder and field and lab performance of mixtures.
2. To conduct traditional Superpave binder tests as per AASHTO M 320 table 1 in order to determine the true grade of binder with various modified binders used in the state of New Jersey.
3. To determine the properties of the polymer modified binders based on table 3 in AASHTO M320 and to determine the recoveries based on the elastic recovery (ER) test.
4. To quantify the molecular weight distributions of polymers present in the binders using Gel Permeation Chromatography (GPC). If necessary, additional tests such as FTIR or NMR will be used to identify and further characterize the polymers.
5. To determine the sensitivity of J_{nr} and percent recovery from MSCR and ER tests.
6. To develop appropriate specification limits and the database of mechanical properties of modified binders and the type of modification of the binder.
7. To provide recommendations to the state of New Jersey on whether parameters from MSCR and ER can be used for the material selection specifications for polymer and CRM modified binders and appropriate specification limits.

BACKGROUND AND RESEARCH PROBLEM

Currently, the Superpave Performance Grade (PG) binder specification, AASHTO M-320, is used throughout the United States to grade asphalt binders (D'Angelo et al, 2007). This asphalt binder specification was based on a strategic highway research program (SHRP) and was based primarily on the study of neat asphalt binders with no polymer additives. The applicability of this specification to the polymer modified asphalt binders raised concerns by industry and state highway agencies. The inadequacy of the Superpave high temperature specification parameter in Table 1 of AASHTO-M320, $G^*/\sin \delta$, to correctly grade the superior field performance of modified asphalt binders has been demonstrated by several researchers (D'Angelo et al, 2007). Therefore, as a replacement for the existing high temperature binder test ($G^*/\sin \delta$), the FHWA has developed the multiple stress creep and recovery test. This test is used to characterize the asphalt binder high temperature properties at which the pavement has to actually perform, in other words, at the environmental use temperatures. As such, many state DOT's have implemented additional tests called Superpave PG Plus or SHRP Plus tests in an attempt to ensure that a modifier is included in the binder. The SHRP Plus tests do not relate to performance but only indicate the presence of a particular modifier in the binder.

At present, the state of New Jersey requires the use of styrene-butadiene or styrene-butadiene-styrene formulations. In-lieu of the polymer shortages, the state of New Jersey would like to expand the use of polymers and rubber in the binder. Before the state of New Jersey can allow the use of other modifiers, there is a need to first determine whether parameters such as the J_{nr} and the recoveries determined from MSCR (and ER) are sensitive to the polymer or rubber modification of the binder.

To meet the Superpave PG specifications set forth by State Highway Research Program (SHRP), asphalt manufacturers either altered manufacturing practices or added modifiers such as polymers to the asphalt binder. From the past research, in general, it is reported that the addition of modifiers improved the performance of hot mix asphalt concrete (HMA) (Hrdlicka, G. M. et al, 2007). Considerable research has been undertaken regarding SBS polymer modified binders (PMB), such as determining the fundamental characteristics of SBS using the conventional bitumen tests like penetration, softening point, thin film oven test (TFOT), penetration and softening point after TFOT, viscosity, Frass breaking point, effect of SBS on aging of SBS PMBs, evaluation of the permanent deformation of SBS modified asphalt mixtures using dynamic creep test, storage stability and compatibility of PMB.

However, not much research is done on the influence of the chemical composition of the polymer modified binders i.e. Styrene-Butadiene-Styrene (SBS), Styrene-Butadiene-Rubber (SBR), Ethylene Vinyl Acetate (EVA) and Poly Phosphoric Acid (PPA) which has considerable effect on the rheological properties of the bitumen by interaction between bitumen and polymer system.(Cortizo et al,2004, Fu . et al,2006, Gonzalez et al,2007, Khodaii and Mehrara , 2009, Mouillet et al, 2007, Ruan et al,2003, Sengoz and Isikyakar ,2007, Stastna . et al,2002, Wen Guian. et al,2001, Zhang and Yu, 2009)

There is a need to emphasize the characterization of the polymer modified binder (PMB) by studying the morphology, i.e. studying the molecular structure of modifier with respect to the chemical composition of asphaltenes and maltenes. The influence of the chemical components within a modified binder on a particular mechanical property of the binder can provide an invaluable tool to the asphalt manufacturer to cost-effectively modify the binder to achieve a “target” mechanical property. This will in-turn benefit the end-user, such as the state DOT’s.

PROGRESS THIS QUARTER BY TASK

TASK 3: CORRELATE MECHANICAL PROPERTIES FROM STANDARD PG TESTS AND PG-PLUS TESTS TO POLYMERS DETERMINED FROM VARIOUS METHODS

In this task, the polymers from various methods will be determined and then correlated with mechanical properties. The research team conducted a detailed characterization of the entire MSCR creep and recovery curve of both in-house and binders from refineries. The parameters that characterize the binders were then correlated to polymer modification. The details of the analysis is shown in Technical Memorandum Q2_11

PROPOSED ACTIVITIES FOR NEXT QUARTER BY TASK

- ✓ Task 2.1: In the next quarter the research team will continue to test and determine the true grade and MSCR properties of additional modified binders sent by NJDOT.
- ✓ Task 2.2: In addition, Elastic Recovery (ER) and Force Ductility will also be conducted on the above mentioned binders
- ✓ Task 3.1: The research team will continue to analyze more PMB’s and more replicates for SARA fractions to study the chemical composition of asphaltenes and maltenes
- ✓ Task 3.2: The research team will conduct Gel permeation chromatography (GPC) and FTIR to determine the polymers and their molecular weights in the modified binders.
- ✓ Task 3.3: The research team will evaluate the influence of the chemical composition of additional base and PMB’s on the mechanical properties of additional base and polymer modified binders.
- ✓ Task 4: The research team will conduct mixture testing.

LIST OF DELIVERABLES PROVIDED IN THIS QUARTER BY TASK

The detailed results, of the following Tasks, were reported within the submitted Technical Memorandum_Q2_2011:

Task 3: Correlate Mechanical Properties from Standard PG tests and PG-Plus tests to Polymers Determined from Various Methods

PROGRESS ON IMPLEMENTATION AND TRAINING ACTIVITIES - SUMMARY OF WORK PERFORMED ON DELIVERABLES

Binder Technology Transfer Workshop Thursday March 17th 2011

The research team conducted a Binder Technology Transfer workshop on March 17th 2011. The workshop was attended by NJDOT, FHWA, and several personnel from plants and refineries. The topics covered in the workshop agenda and the handouts of slides are in Technical Memorandum Q1-2011.

Task 1: The results of this task were documented in the appendices of the 1st and 2nd Quarterly Report of 2010.

Task 2: The results of this task continue to be documented in the quarterly technical memorandums.

Task 3: The results of this task continue to be documented in the quarterly technical memorandums.

Task 4: The results of this task continue to be documented in the quarterly technical memorandums.

Task 5: Not begun yet.

PROBLEMS/PROPOSED SOLUTIONS

The Asphalt Mixture Performance Tester is currently going through approval process within the university.

Total Project Budget	\$398,926.00
Modified Contract Amount:	
Total Project Expenditure to Date	\$262,094.65
% of Total Project Budget Expended	65.7%

NJDOT Research Project Manager Concurrence: _____ Date: _____